

# REPORT

August 2016

## ScienceBEAT and ScienceBEAT.org

*An Interdisciplinary Collaboration Between Researchers  
From Four University of Maryland Departments and  
Three Prince George's County Public High Schools*



UNIVERSITY OF  
MARYLAND



Prince George's  
County Public  
Schools

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## EXECUTIVE SUMMARY

Grounded in Next Generation Science Standards (2015) and the Common Core State Standards Initiative (2010), the ScienceBEAT initiative was proposed, developed and is now evaluating interactive educational modules that address the many dimensions of climate change. Although every team member in the project shares a passion for educating students and citizens about climate change, the idea to combine science with English/journalism classrooms originated with co-PI Ronald Yaros who, as a science reporter for a St. Louis television station in 1981, completed the nation's first video reports on one of the first EPA reports titled, "Greenhouse Effect." The field of journalism includes specific news "beats," including health, science, and education, for example. The project's name "ScienceBEAT" represents the interface between the latest science research the public should know with accurate and balanced media coverage that the public should understand

All work presented in this report is the product of unique and interdisciplinary collaborations between University of Maryland researchers from four Colleges (Computer, Mathematical, and Natural Sciences; Education; Journalism; and Public Health) plus classroom teachers and high school students from three Prince George's County Public Schools including DuVal, Northwestern, and Eleanor Roosevelt High School.

Specifically, University of Maryland researchers and PGPCS high school teachers of earth science and English or journalism worked together to develop and pilot test a series of digital learning modules. These interactive modules - available as PowerPoint slides or mobile iPad presentations – were shared by science *and* English or journalism classrooms. The modules were designed to enhance the students' awareness and understanding of critical climate data and foster more accurate and explanatory communication of climate change.

The twelve *ScienceBEAT* modules (six for science and six for English/journalism classrooms) synthesize the latest climate and health data, which are analyzed by science students and simultaneously, evaluated then explained using text written by English and journalism students. This unique interdisciplinary approach to the major risks of climate change by two areas of study in high schools is expected to produce a more engaging and educational experience as students contemplate the critical global issues of climate change.

ScienceBEAT modules are based on the latest reliable and accurate information about climate change and the most effective strategies for teaching the critical reading and writing of informational text. This also includes, in part, the testing of new educational technology to enhance student interactivity, engagement, and learning of science. ScienceBEAT addresses the well-documented knowledge gaps in the public's understanding of climate change impacts (Wilson et al., 2010) and the often overlooked value of explaining accurate information (i.e., critical reading and writing) about complex science. The data collected from this research offer valuable results and additional opportunities for external funding.

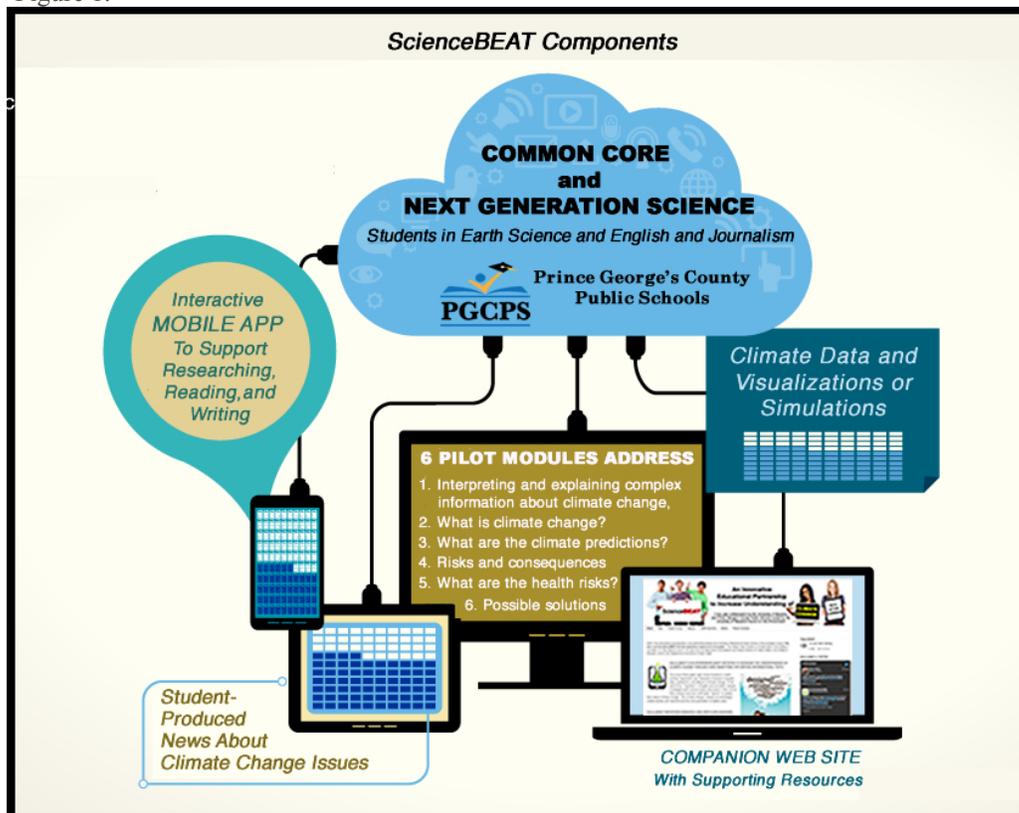
Synopsis of the ScienceBEAT project:

- Regular team meetings to discuss and develop classroom modules about climate change.
- Interactive modules (6 science, 6 English/journalism) including the latest data on climate change.
- Synthesis of modules for presentation/discussion in science *and* English/journalism classes.
- Development of "sciencebeat.org" as an informational web site for teachers.
- Development of three reliable and valid measures of student attitudes and knowledge gain.
- Institute Review Board approvals from UMD and Prince George's Office of Research.
- Paid teacher training sessions on the UMD campus plus classroom visits for observation.
- Quantitative data collection of student outcomes and qualitative evaluations of modules from teachers.
- Preliminary analyses (Aug 2016) suggesting statistically significant improvement by students in understanding climate change including its predications, risks, consequences, and possible responses

## PILOT PROJECT DESIGN

As illustrated in Figure 1, the key components of the ScienceBEAT pilot project address the latest information about climate science in alignment with “common core” and “next generation science” objectives. The six initial modules developed introduce the importance of good communication of complex information such as climate change and an analysis of how that complexity is CURRENTLY being addressed by today’s mass media. This comparison allows students in both science and English/journalism to investigate the information and the sources being emphasized by the media for general audiences. Subsequence modules: (1) define what climate change is, (2) elucidate the various predictions, (3) outline the risks and consequences of such predictions, (4) focus on some key health issues that develop from significant changes in climate and conclude with (5) possible solutions that could begin now.

Figure 1.



One of the key questions explored by this project is the extent to which high schools have the technology and teacher have the training to utilize cutting-edge technology for enhanced student interactivity and engagement with the content. Two separate versions of each module were developed. One version including PowerPoint slides for classroom presentation and discussion. The second version produce interactive slides for student with access to mobile devices (i.e. phone and/or tablets). Using a licensed third-part app called “Nearpod,” each module supported the teacher as s/he used their computer, laptop, or mobile device to share interactive slide with students on THEIR mobile device. This technology addresses the concern that students might be distracted by mobile devices with relevant and interactive classroom content ON their mobile devices. Any “distraction” from the device, therefore, is for content being presented and/or discussed in class.

The scholarly merit of this initiative is paramount with research questions that address three key processes (Rachlinski, 2000).

Research questions explored by the ScienceBEAT project include the three educational components of:

### 1. EXTENSION

**RQ1a:** *How can current curricula about climate be extended to address the predictions of climate change?*

**RQ1b:** *How can current research and best practices on the critical reading and writing of informational text be extended to address the complexities of science text, more specifically, climate change?*

### 2. ENHANCEMENT

**RQ1a:** *What are the latest and most valid and reliable scientific analyses related to climate change?*

**RQ1b:** *How can climate change be accurately explained to non-experts using digital tools and media?*

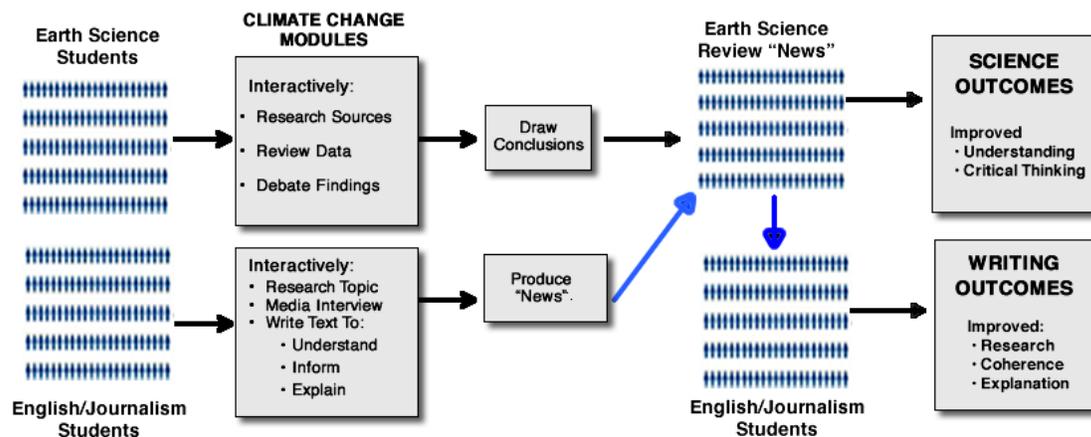
### 3. ENGAGEMENT

**RQ1a:** *What are the debates related to the causes and effects of climate change?*

**RQ1b:** *What is the range of possible solutions that address the causes and effects of climate change?*

## LITERATURE AND THEORY

As illustrated below, students in each discipline simultaneously review and interact with the ScienceBEAT modules that emphasize either the science behind climate change OR the writing and communication of climate change. Students in science classes research, review, predict, and debate various aspects of climate change while the writers in English and journalism classes interpret the research and work to explain it to general audiences. If possible, the student writers might even interview the science students. Alternatively, the science students might read and peer review the writers' narratives for accuracy. The goal is to improve understanding and critical thinking of climate change by students in both disciplines.



### *Next Generation Science Standards*

The framework for the goal that all students should learn about the relationships among science, technology, and society is based on two core ideas. The first idea is the *interdependence* of science, engineering, and technology. The second idea is the *influence* of engineering, technology, and science on society. These are based, in part, on the premise that advances in technology provide scientists with new capabilities to probe the natural world on larger or smaller scales; to record, manage, and analyze data; and to model increasingly complex systems with greater precision. (NRC, 2012, p. 203). This ScienceBEAT pilot capitalizes on the interface of technology with science and English because it includes technology that facilitates engagement and enhances involvement with science and a focus on climate change.

While it has long been recognized that building home-school connections is important for academic success, this is rarely done in an effective manner. There is often a perceived disconnect between the science practices taught in schools and the science supported in the homes and communities. ScienceBEAT helps to build new connections between scientists and non-scientists (i.e. writers) by providing a natural interface between classrooms of different disciplines and engaging students in both disciplines with the need to define problems then design solutions to prepare for risks of climate change.

## **DEVELOPMENT OF PILOT MODULES**

### **Objectives of lessons and classroom implementation**

With guidance from the participating teachers, the team of UMD researchers began meeting regularly in July of 2015 to develop and then validate the proposed innovative initiative. The team's goal was to obtain and nurture a mutually beneficial relationship with participating high school teachers from Prince George's County. To begin, the team worked together on the six *ScienceBEAT* lessons to identify and then synthesize the latest climate and health data to be analyzed in science classes and to be interpreted for critical reading and writing of informational text in English and journalism classes.

Instead of devoting a portion to the week to each lesson, the initial design was for teachers to use the lessons in selected class periods. This could mean sequential classes across three weeks or, if the teacher prefers, selecting class meetings that would be devoted to ScienceBEAT. Every lesson was designed to span classroom time as follows:

**Before the project begins:** Pre-test student knowledge and attitudes

**Class meetings one and two:** Present/Discuss Module X

**Third class meeting:** Review concepts and assess learning from Module X

Then introduce concepts for the subsequent Module Y.

**Class meetings four and five:** Present/Discuss the next module.

Suggested classroom timing included:

**First 30 minutes:** Present and discuss the ScienceBEAT concepts, followed by **approximately thirty minutes** of hands-on and interactive activities guided by the teacher.

**Final 10 minutes:** Knowledge test

This format above was used to design all six modules as described in the next section.

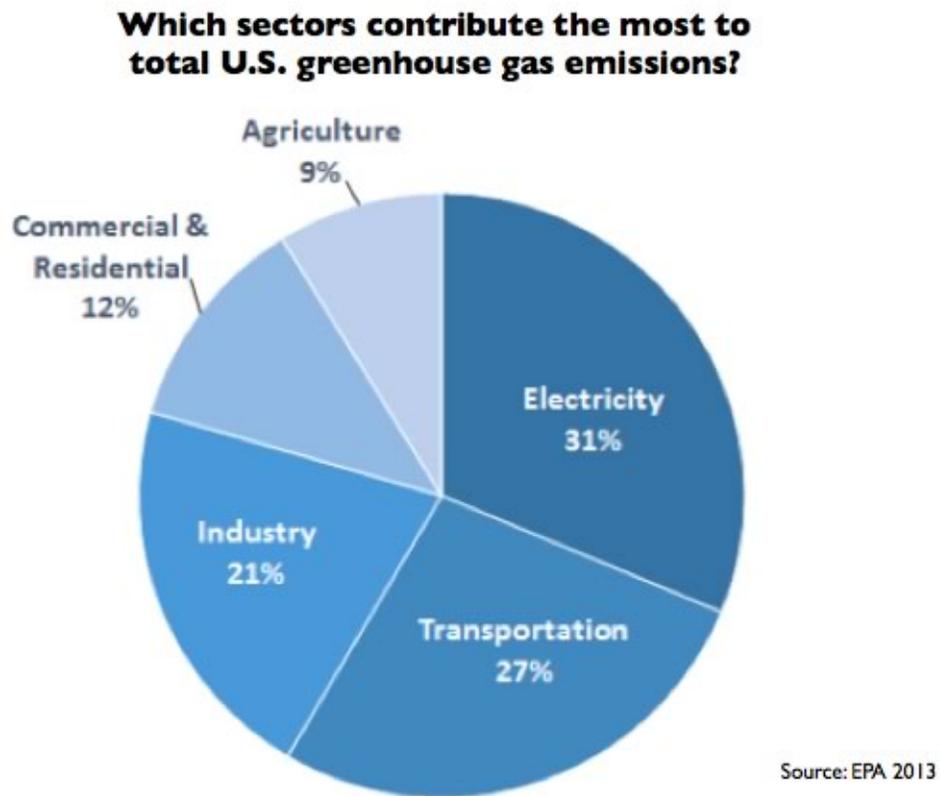


## Module 1. *Interpreting and explaining complex information about climate change*

### Objective:

Students will learn strategies to interpret and write three different types of explanatory text for science and health topics such as climate change (Rowan, 1985, 1999).

Module 1 introduces students to research-based evidence and examples from science journalism and educational psychology (Mayer, 1985) that address how digital users seek, select, share, and learn from media (Tremayne & Dunwoody, 2001). The challenge is competing with an overwhelming amount of online information to inform the public, especially when younger users are not engaging with important topics because they can't understand it or can't apply the information to their own lives. The key is to present important data in clear yet concise ways. Visualization, explanatory writing, and the implementation of techniques that address today's digital audience are stressed. The follow example illustrates the key components of effective graphic communication to non-experts.



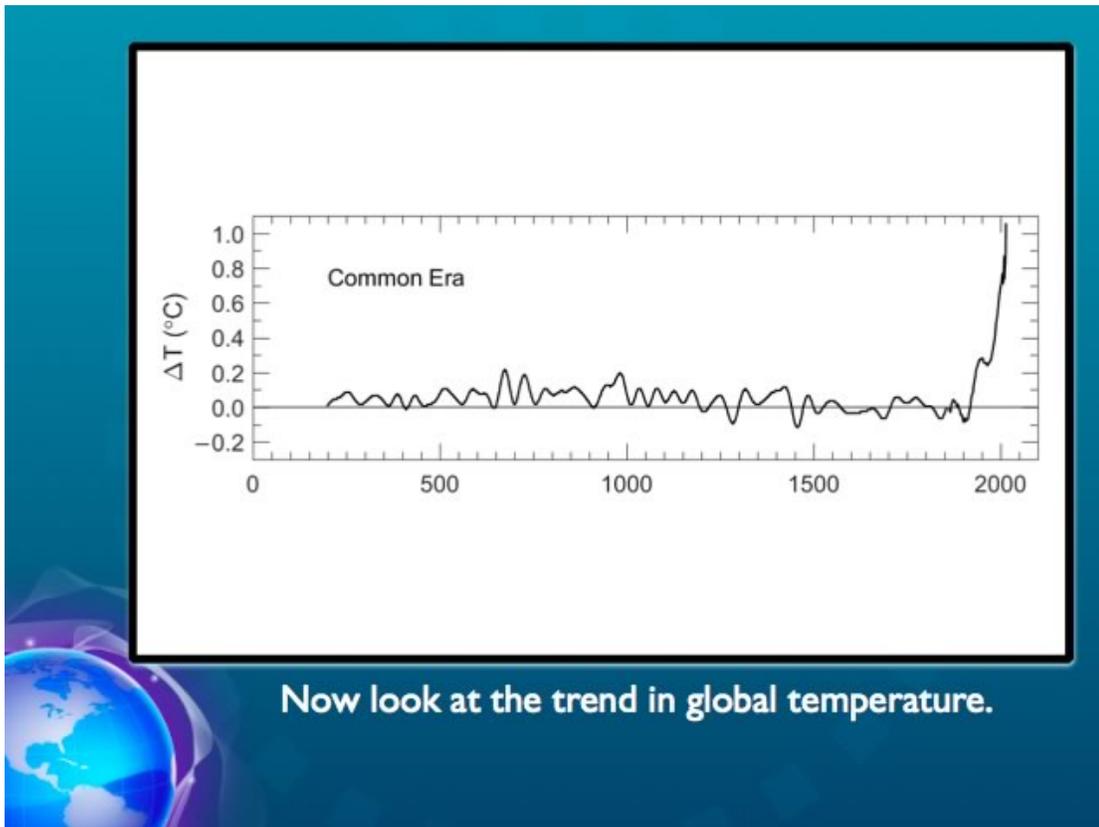
Module 1 also guides students in how to structure clear explanatory text about climate change for general audiences and reviews the four key components of: personalization, interactivity, coherence of media (text, data graphs, video, etc.) with minimal “kick-outs” (or elements that terminate user engagement and understanding).

## Module 2. *What is climate change?*

### Objective:

Students will learn the basic factors that govern human and natural influences on global climate.

Module 2 explains that climate is the long term average of weather and will outline how human activities have modified past climate and may influence future climate.



The focus of module 2 is the rise in global mean surface temperature (GMST) from pre-industrial to the present (Canty, Mascioli, Smarte, & Salawitch, 2013). Using a series of graphic elements, students analyze the unmistakable human fingerprint on GMST over time.

This module also quantifies the effects of solar activity, oceanic processes, and major volcanoes on climate and introduces the conundrum affecting the accuracy of climate predictions. This also includes the uncertainty of aerosols on the rate of warming. Students in English and journalism classes write informational texts that explain these uncertainties and processes to a general audience.

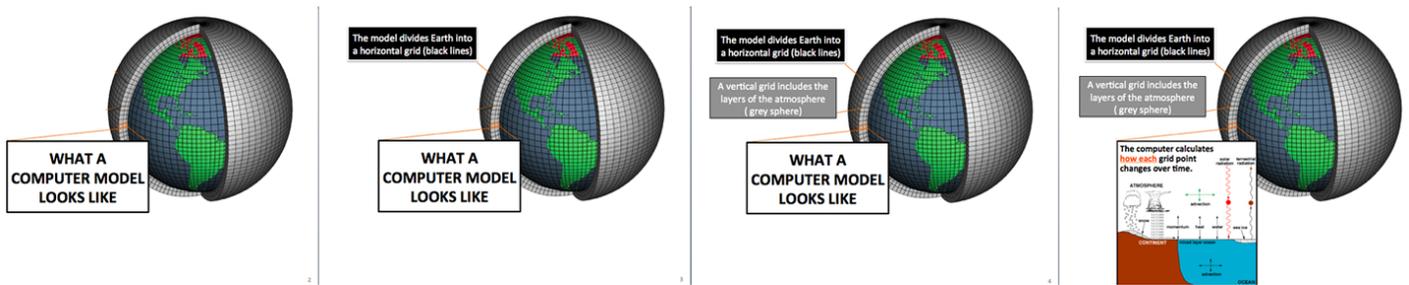
### Module 3. What are the climate predictions?

#### Objective:

Students will investigate how scientists make projections of future climate and the uncertainties inherent in these predictions (Mascioli, Canty, & Salawitch, 2012).

This module begins by defining a “computer model” followed by the positive and negative feedback mechanisms in the atmosphere, which enhance or diminish the influence of greenhouse gases on climate.

Here is a sample slide sequence describing a computer model:

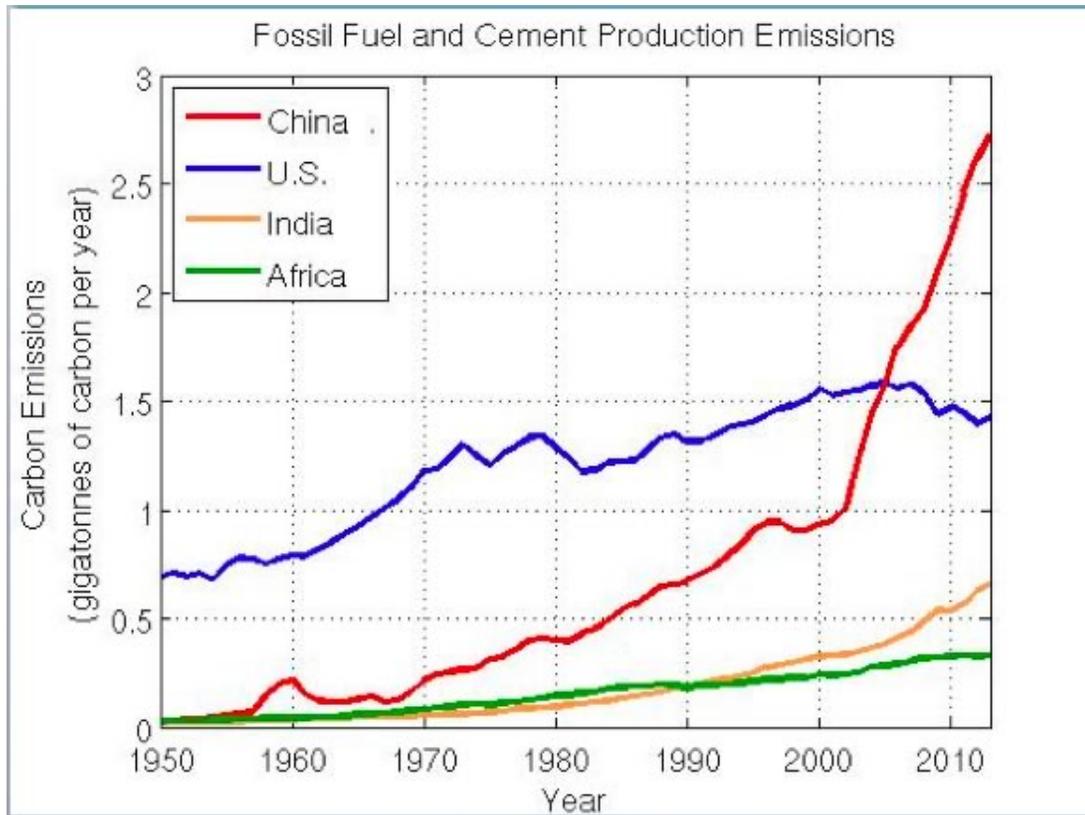


The module establishes the importance of proper quantification of climate feedback for reliable projections of future global warming. Building off of Module 2: we show that the uncertainty of future warming is due mainly to the cantilevering between the strength of radiative forcing of climate by tropospheric aerosols and climate feedback, both of which are not well known.

Students in both science and writing classes review critical evaluations of the climate projections by the Intergovernmental Panel on Climate Change (IPCC, 2013). Students in English and journalism read, discuss, and then write informational text that addresses an important axiom of science: predicting the future is much harder than understanding the past.

#### Module 4. *What are the risks and consequences of climate change?*

**Objective:** Students will learn how climate change impacts many aspects of the earth system from a local to global scale.



Module 4 outlines the human impact of climate change from the perspectives of sea-level rise, loss of habitats, ocean acidification, and the increasing likelihood of extreme weather events (IPCC, 2013).

Module 4 emphasizes the apparent transformation in the Earth's climate system: the expansion of the tropics, the pole ward shift of the mid-latitude weather systems that are leading to rapid warming, particularly in the Arctic region.

By the end of module 4, students recognize the risks and consequences of climate change and identify possible responses to the urgent need to slow the rate of warming. Students in English and journalism classes produce informational text that *accurately* explains the consequences of climate change and how different populations are expected to experience different effects.

## Module 5. *How could climate change affect you?*

**Objective:** Students will learn how climate change is impacting the health of individuals at a local and national level.

Module 5 focuses on and then expands the effects of increased extreme weather events such as heat waves, cold waves, and excessive precipitation, as well plant and animal life cycle events that are influenced by changes in climate.

Students examine how these events are deviating from the long-term trends in Maryland and the Continental US. Students learn how to articulate why the increased frequency/severity of extreme events and the alteration in plant and animal habitats are affecting the health of Marylanders.

This is a sample screen from the journalism module introduces a brief interview with a senior scientist explaining threats to our health. Students distill the information and compose/explain the details in their own news stories.



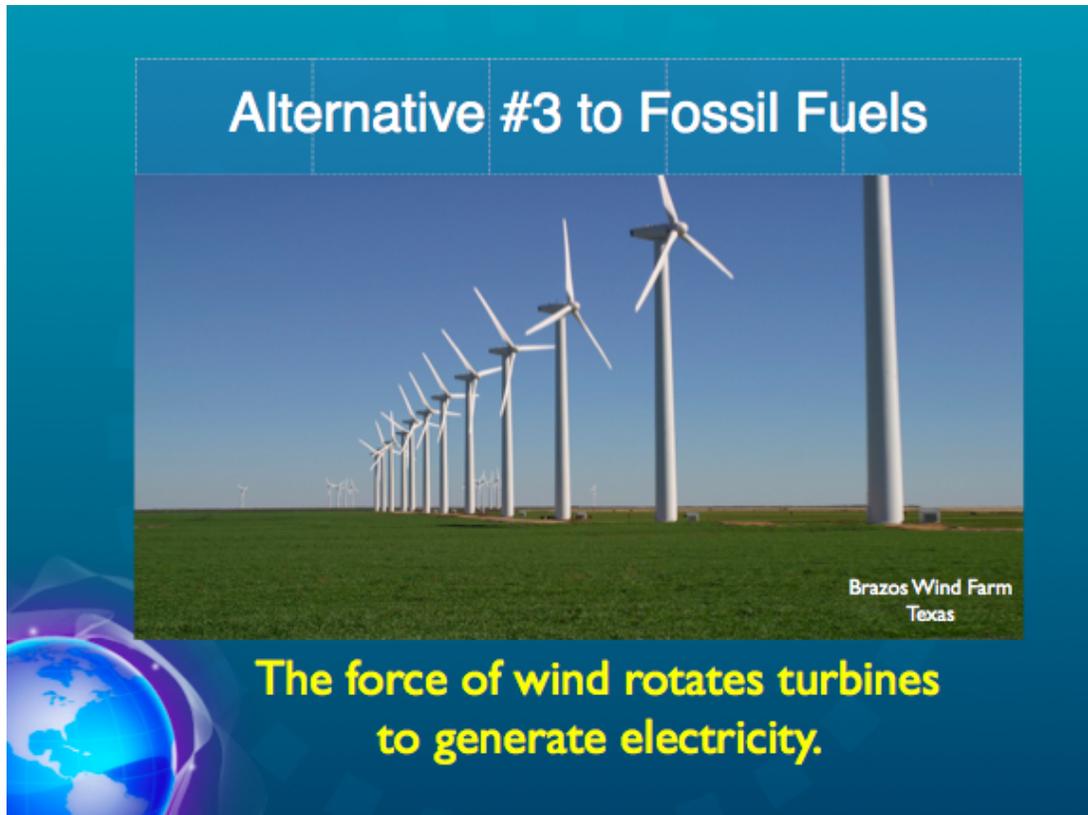
The focus of Module 5 is on at least three examples of chronic and infectious diseases that correspond to the extreme events and changes including:

- (1) Extreme summer heat and increased risks of heart attack,
- (2) Increased precipitation and risks of bacterial infections, and
- (3) Changes in plant and animal habitats, higher pollen associated with increasing greenhouse gases and, and increased risks for asthma.

Students compose informational texts that explain the vulnerability and susceptibility to health conditions related to climate change.

**Module 6. *What are possible solutions for climate change?***

**Objective:** Students review the economics and complex governance issues that drive global climate change and the importance of personal choices for transportation, diet, and entrepreneurship.



The economics of climate change are addressed in Module 6 by outlining the relative costs of energy production by solar, wind, hydro, nuclear, and fossil fuels plus the costs of generating energy by each method.

Global governance issues are examined by focusing on the impacts of population growth and the necessity of the Developed World to assist economic growth in the Developing World while reducing the dependency on fossil fuels, which have been historically over used in the Developed World.

The module refers to websites that invite students to calculate the possible effects of their personal carbon footprints. Students also discuss specific actions to reduce carbon footprints and write explanations for why cooperation between governments could reduce the rate of warming.

Students in English and journalism classes produce informational texts that explain how personal choices contribute to possible solutions. They are also provided with the option to interview their peers in science classes as “ScienceBEAT student experts.”

The following “task reports” summarize the specific tasks completed by individual ScienceBEAT units on the University of Maryland campus.

## LEARNING TECHNOLOGY

All modules utilize PowerPoint slides. Not surprisingly, most teachers have the resources to display PowerPoint slides for classroom discussion or to distribute the slides for later viewing by students.

An innovative aspect of the ScienceBEAT development was to utilize the mobile application, “NearPOD” so that teachers would have the option to use mobile devices in class, if devices are available. NearPOD has been tested and successfully used by co-PI Ronald Yaros in his UMD i-Series journalism course since the spring of 2014. Testing for student engagement and learning continues since the unique app features more than 15 activities for classrooms (i.e. polls, open ended questions, live web links and drawings, YouTube videos, managed quizzes, etc.). Using the app on a school’s WIFI network, students login on their device with a teacher-provided PIN (no account needed) and the teacher advances through the presentation on his/her iPad. All slides and activities on the teacher’s device are simultaneously displayed on the students’ devices.



Classroom poll summaries and even selected student responses can be instantly shared (anonymously) with the class in real time. In addition, student responses are collected for later evaluation by the teacher. The licensing of NearPOD by ScienceBEAT provided access, development, and testing of the following components:



ScienceBEAT modules developed for NearPOD and are available to teachers with PowerPoint slides. Although most classrooms do not yet have tablets for students, all pilot teachers expressed strong interest in future funding that might provide pilot classrooms with the mobile devices for future ScienceBEAT testing.

The following are “Unit Task Reports” submitted by each departmental team at the University of Maryland

### **UNIT TASK REPORT: Atmospheric Science**

The Department of Atmospheric and Oceanic Science (AOSC) team performed the following actions during year one of the ScienceBEAT project:

- Senior members of our team contributed to outlining the project and writing the initial grant proposal
- Four AOSC team members attended weekly meetings of the entire ScienceBEAT team (Journalism, Education, Public Health, and AOSC), at which the project basics were implemented and the structure of the modules was designed
- The AOSC team led the construction of four of the six modules included in the ScienceBEAT project.
  - Module 2: What IS Climate Change? Ross Salawitch provided content that introduced the basics of Earth’s climate and explained some of the specific components of climate change, emphasizing how greenhouse gases lead to global warming.
  - Module 3: What ARE the Predictions? Austin Hope provided content that described how various climate models work and outlined the changes in climate that are forecast by these models, with an emphasis on temperature rise as well as the difficulties of predicting the future compared to explaining the past.
  - Module 4: What Risks and Consequences are Possible? Timothy Canty provided content that described the risks of global warming, including severe weather events, sea level rise, and loss of Arctic habitat, all with linkages to the human condition.
  - Module 6: What are Some Solutions? Walter Tribett provided content that explored global and local-level actions that can be taken to slow down the rate of global warming, ranging from international agreements, to alternate energy sources, to personal choices regarding diet and transportation.

For each module, we:

- described the state of the science at what we thought was the high school level, using graphics, figures, tables, and short paragraphs.
- compiled resources from various sources including government agency data, the scientific literature, as well as our own research conducted at the University of Maryland; a list of URLs was included in each module
- provided learning objectives, which actually guided the construction of each module.
- provided final quiz questions, as well as interactive questions and polls within the material

Finally, the four researchers from AOSC met with Prince George’s County high school teachers to introduce the modules, answer questions, and receive feedback.

As a result of a contact made at this meeting, Ross Salawitch participated as a keynote speaker at DuVal High School on 2 June 2016, for their World Environment Day celebration.

## **TASK REPORT: College of Education**

The Department of Teaching and Learning, Policy and Leadership (TLPL) Team performed the following actions during year one of the ScienceBEAT initiative:

- The senior team member, Wayne Slater, contributed to conceptualizing, outlining, writing, and revising the initial grant proposal.
- The two TLPL team members (Wayne Slater and James Groff) attended weekly meetings of the ScienceBEAT team (Journalism, Public Health, Atmospheric and Oceanic Science, and TLPL), at which project basics were implemented and the structure of the modules was designed and critiqued.
- The TLPL team conducted comprehensive research literature searches on climate change and its effects and the teaching of environmental science in secondary schools (McKeldin Library, the Library of Congress, the National Medical Library, and the National Agricultural Library).
- The TLPL team contributed to the construction of the six modules included in the ScienceBEAT initiative.
  - We constructed pre-tests and post-tests for each of the six modules assessing validity and reliability.
  - We constructed a comprehensive pre-test and post-test covering the content all six modules assessing validity and reliability.
  - We constructed two climate change student attitude scales addressing climate change issues addressed in all six modules.
- The senior team member on behalf of ScienceBEAT initiated contact with the Prince George's County Public Schools (PGCPS) regarding piloting the ScienceBEAT initiative in three high schools: DuVal, Northwestern, and Eleanor Roosevelt. With the support of Associate Dean Margaret McLaughlin, College of Education, he organized and conducted an initial meeting with PGCPS on September 4, 2015, with the following PGCPS professionals: Godfrey Rangasammy, Science Supervisor (PreK-12), Corey Carter, Supervisor, High School Reading/English Language Arts; Lorrie Ann Armfield, Science Instructional Specialist (Pre-K-12); Karen Shaw, Reading/English Language Arts Instructional Specialist (9-12); and Maryland's College of Education Associate Dean Margaret McLaughlin.
- The senior team member secured final PGCPS Research Office approval of the ScienceBEAT pilot study in the three target high schools.
- The two team members contacted the high schools, secured building principal approval, in-serviced the pilot study participating teaching, systematically observed the teacher implementation of the ScienceBEAT modules, and assisted in data collection at the three research sites.
- During the summer of 2016, the senior team member recruited and supervised two participating PGCPS pilot study teachers, Audrey Ruoff and Rebecca Hammonds, in revising the ScienceBEAT modules based on pilot study data; and recruited a PGCPS instructional specialist, Jonathan Wemple, to conduct a second level review and revisions to the pilot modules.

## **TASK REPORT: School of Public Health**

### **Summary:**

The health team included Amir Sapkota and MPH Candidate Allison Gost. Our module aimed to introduce and educate the individuals on the health effects of climate change. The previous ScienceBEAT modules addressed what climate change is and what some of the impacts are. Our goal was to link the physical components of climate change to individuals and show them where, when, and how their health, or the health of their families and communities may be impacted by climate changes. The literature shows that there is a direct link and that overall health is impacted in different ways depending on the characteristics of the communities where changes in climate occur. We did not provide a comprehensive description of all of the health effects, but begin to build bridges in the minds of students. We wanted to show the students first hand examples of both health impacts to their community and other communities.

### **Key components**

Typically, the health component is left out of climate change discussions. We felt it was critical to the successful understanding of climate change to explain the health impacts that individuals can expect to see. Additionally, for future citizens to understand that many health events we are experiencing are directly or indirectly attributed to climate change. This link isn't always obvious in popular media reports. We also wanted to emphasize that these health conditions are not something that might happen in the future – but that climate change is impacting the health of many living creatures, regardless of race, religion, country or origin, or socioeconomic class, and will continue to do so in an increasing rate. A final important component that we emphasized was that combating the physical representations of climate change is not enough to protect one's health. Separate, but parallel programs need to be developed and implemented around the world, at different levels, to improve baseline health, improve resiliency of the populations and adapt their lifestyles and health care to the already changed system to be more efficient and equitable.

### **Our efforts**

We started with six main categories of health impacts: health risks from water, air, food, vector-borne diseases, mental health and extreme events. As we developed the modules, we broke the health impacts into direct and indirect effects. For example, a direct impact of extreme rain events is drowning from flooding, while an indirect impact would be the spread of water-borne diseases (such as cholera) in the days, weeks, and months following the event. The direct, indirect, and risk of any of the six categories vary by region, population at risk, vulnerable populations, and increasing severity or frequency as climate change continues. In this pilot program, the modules did not provide us with the time to delve into each example, but we did keep our efforts and content focused on those main categories, providing examples related to our audience (PG County, State of Maryland, etc.) while also providing a global perspective. Throughout the iteration process, we developed and tweaked many interactive elements – from reading a newspaper clipping, and summarizing it to the class, to reading the abstract of a scientific article. We developed multiple choice quiz questions (T / F and open ended) plus diagrams for interpretation. Our team knew that we needed to make this module interactive and engaging. Module 5 aimed to guide students in understanding the health effects of climate change, and to encourage students to make a connection between their own health and climate change.

## **TASK REPORT: College of Journalism**

The Philip Merrill College of Journalism performed the following tasks during the first year of the ScienceBEAT initiative:

- Senior team member Ronald Yaros distributed all funds as proposed to each of the UMD units for the support of graduate research assistants and to vendors for software licensing.
- Ronald Yaros organized regular team meetings based on the availability of all faculty members and graduate assistants to plan the ScienceBEAT modules for implementation in high school classrooms.
- Two team members (Ronald Yaros and Wayne Slater) produced the application and consent forms for classroom research as required by the University of Maryland Institute Review Board and the Research Office of the Prince George's Public Schools. Consent forms included those for teachers, students and parents. Approval to proceed with the research was granted from both offices.
- Ronald Yaros and journalism graduate research assistant Alexander Quinones conducted comprehensive research related to the communication of complex information to general audiences (i.e. non-scientists).
- Ronald Yaros and GA Alexander Quinones reviewed the initial science modules developed by the team then adapted the science content to six new modules for ScienceBEAT English or journalism classrooms. Specifically,
  - We constructed modules that emphasized good research and writing.
  - We included lessons that challenged students to become critical evaluators of science news.
  - We constructed journalism modules that complimented the science modules, requiring students to verify the sources and information presented and then to obtain additional information or explanations about the information from other scientists and their peers in science classrooms.
- Senior team member Ronald Yaros monitored and managed activities of the team from the College of Education to secure final PGPCS Research Office approval of the ScienceBEAT pilot in the three target high schools. He and the senior team member from Education (Wayne Slater) conducted on-site visits for meetings with the principals and teachers at each of the target high schools.
- Ronald Yaros and GA Alexander Quinones contacted the teachers at each high school to coordinate a ScienceBEAT meeting held at Knight Hall (with the UMD team) on Saturday, April 16. This meeting was also coordinated with the regular Saturday "mobile journalism" class in Merrill's certificate program so that the project could be "covered" by UMD students in the certificate program.
- During the summer of 2016, Ronald Yaros and the senior members from education interviewed two PGPCS pilot study teachers (Audrey Ruoff in journalism and Rebecca Hammonds in science).
- During the summer of 2016, Ronald Yaros began new research on possible sources for future external funding to support continued development and expansion of the ScienceBEAT project.

## INITIAL PILOT RESULTS

Analyses of classroom data collected in May and early June 2016 began in July 2016. Due, in part, to an unforeseen delay by Prince George’s Public Schools to grant its final approval of the ScienceBEAT project in the spring of 2016 (as opposed to the expected approval date in the fall of 2015), a significant portion of the classroom data continues to be analyzed.

However, preliminary reports are submitted here following data entry and analyses of test scores in July and August 2016. A total of 607 responses were collected from students in the target high school classrooms. (Three student responses were dropped since they did not complete the post-tests. The produce a final sample of 604 responses to the four different instruments of: (1) Pre-pilot knowledge of climate change, (2) Post-pilot knowledge of climate change, (3) Student attitudes toward climate change, and (4) Student perceptions of what climate scientists believe. The following is the distribution of responses collected by classroom and instrument.

		Select Teacher/School then scroll down to the instrument then add values. LEAVE BLANKS for any qu...					
		Molly Ahearn / DuVal journalism	Ms. White / DuVal science	Audrey Rouff / ROOSEVELT journalism	Rebecca Howell-Hammonds / ROOSEVELT science	DeBelen / Northwestern	Total
Instrument	PRE KNOWLEDGE 28Q	34	22	16	0	0	72
	POST - KNOWLEDGE 28Q	38	17	0	77	3	135
	6 Attitude - 6 questions	0	22	17	53	102	194
	27 Scientist - 27 questions	1	24	18	48	112	203
	Total	73	85	51	178	217	604

The following is the total count of student responses by instrument.

#	Field	Choice Count
1	<b>PRE KNOWLEDGE 28Q</b>	11.86% 72
2	<b>POST - KNOWLEDGE 28Q</b>	22.24% 135
3	<b>6 Attitude - 6 questions</b>	32.13% 195
4	<b>27 Scientist - 27 questions</b>	33.77% 205
		607

In terms of knowledge gain about climate change (that is, comparing pre and post test measures), nearly double the amount of post tests were administered by classroom teachers than before the project began. Therefore, to perform a valid *t-test* statistical comparison, a sample of 72 post-test responses – to match the 72 pre-test responses - was established with a random sampling of 72 responses from the post-test data set of 135 responses.

## t-Test Results

Descriptive statistics indicated that post test scores on the 28 item instrument of knowledge (N=72) were higher ( $M = 14.2, SD = 4.0$ ) than the pre test scores (N=72) of knowledge about climate change ( $M = 10.6, SD = 3.4$ ). A

To test for significance in this difference, an independent sample t-test analysis indicated that the difference in pre and post knowledge of climate change was statistically significant ( $df = 142, t = -5.65, p = <.001$ ).

## T-Test

Group Statistics

Instrumt	N	Mean	Std. Deviation	Std. Error Mean
Knowledge PRE Knowledge 28	72	10.6111	3.44189	.40563
Knowledge POST Knowledge 28	72	14.1528	4.05476	.47786

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Knowledge	Equal variances assumed	1.671	.198	-5.650	142	.000	-3.54167	.62681	-4.78074	-2.30259
	Equal variances not assumed			-5.650	138.350	.000	-3.54167	.62681	-4.78102	-2.30231

## Limitations

Although the statistically significant increase in knowledge about climate change was a welcomed result from the pilot project, it is important to acknowledge that the pilot's sample of 72 student responses was relatively small.

Also, the "between subject" statistical test compared classrooms from different schools even though all students in science and English or journalism completed the same pre and post test instrument.

This fall, we will conduct additional analyses to isolate results from only science or writing classrooms to gain more insights into the effectiveness of the project on knowledge gain by discipline. These initial results, however, are still encouraging and will be used as evidence for future research to be supported by external funding.

## Teacher and Instructional Supervisor Reviews (in progress)

To triangulate our recommended revisions to the ScienceBEAT modules, we implemented a two-tier approach for review of the materials by those who teach them. This approach includes two ScienceBEAT teachers and one Prince George's County Public Schools (PGCPS) instructional supervisor.

Working independently in July 2016, the two PGCPS teachers provided extensive feedback on the ScienceBEAT climate change and English/journalism modules. After they completed their reviews, the PGCPS instructional supervisor provided his independent review of the modules in August 2016 and was then provided with the reviews submitted by the two teachers. The supervisor reviewed the suggested revisions and recently provided a review of their reviews so that we can rank the significance of teach recommendations in relation to the curricula and instructional practice in Prince George's County Public Schools.

## FUTURE DEVELOPMENT AND FUNDING

Our next immediate step for the ScienceBEAT project is to incorporate the suggested modifications from classroom teachers (see appendix for a sample teacher response) for each module. We are now planning to host the second of two paid teacher-training sessions (with the remaining funds from the original award) to be held at a PGPS facility and then embark on a revised pilot study to test the effectiveness to the revised materials.

In terms of funding beyond our second pilot this fall, we are now formulating how the health module of ScienceBEAT can lead to a proposal for funding from the National Institute of Health. It would appear that the combination of climate change and its health effects would be of interest to NIH to educate the generation of citizens.

Clearly, the “Science, Technology & Society” division of the National Science Foundation is a natural target for subsequent funding and development of this novel community-based project that addresses an important topic at a critical time. (See the STS description below for more details.) Efforts have already begun to outline the key components of an NSF external grant, which we hope to conclude after the next final revision of the ScienceBEAT materials. We believe that the “proof of performance” from the six pilot modules locally could be expanded to at least 12 modules for utilization in high school science and English classrooms across the nation. We also believe that adapting these modules to hands-on interactive mobile learning (using tablets and phones) represent an innovative strategy to engage high school students with the science behind the predicted climate changes. **A proposal now under discussion will be submitted to NSF on or before February 2, 2017.**

## **Science, Technology, and Society (STS)**

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### **PROGRAM SOLICITATION NSF 15-506**

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### **REPLACES DOCUMENT(S): NSF 12-509**

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**National Science Foundation**

**Directorate for Social, Behavioral & Economic Sciences  
Division of Social and Economic Sciences**

**Full Proposal Deadline(s) (due by 5 p.m. proposer's local time):**

**February 02, 2015**

**February 2, Annually Thereafter**

**August 03, 2015**

**August 3, Annually Thereafter**

According to the targeted programs on NSF web site:

“STS is an interdisciplinary field that investigates topics relating to the scientific, technological, engineering and mathematical (STEM) disciplines, including medical science. STS research uses historical, philosophical, and social scientific methods to investigate STEM theory and practice with regards to history and socio-cultural formation, philosophical underpinnings, and impacts of science and technology on quality of life, culture, and society. STS researchers strive to understand how STEM fields contribute to the development and use of systems of knowledge, the production and use of materials and devices, the co-evolution of socio-technical systems and their governance, and the place of science and technology in the modern world.

STS research focuses on the intellectual, material, and social facets of STEM. Such research endeavors to understand how scientific knowledge is produced and sanctioned, and how it is challenged and changes. It explores broader societal ramifications and underlying presuppositions. STS research studies how materials, devices, and techniques are designed and developed; how and by whom they are diffused, used, adapted, and

rejected; how they are affected by social and cultural environments; and how they influence quality of life, culture, and society. STS research explores how socio-cultural values are embedded in science and technology, and how issues of governance and equity co-evolve with the development and use of scientific knowledge and technological artifacts. The STS program supports proposals across the broad spectrum of STS research areas, topics, and approaches.

Effective STS proposals will clearly present the research questions, describe and explain the suitability of the methods to be used to address those questions, and provide a detailed work plan with a timeline that demonstrates adequate resources and access to any required data. If the plan involves research at archives, working in specific labs, or engaging with pertinent community groups, it is important to provide evidence of access and to indicate the specific questions to be asked or addressed. If the plan involves surveys, the proposal should discuss sample selection and survey design and content. Similar advice pertains for other modes of STS research involving focus groups, ethnographies, modeling, conceptual analysis, and so forth. Effective proposals suitably situate the proposed project in pertinent STS literatures, issues, and conceptual or theoretical frameworks, and articulate how the results of the proposed project would serve to advance STS, or subfields thereof.”

## FOUNDATION SUPPORT

At least three of the four key program areas of interest expressed by the Alfred P. Sloan Foundation (see screen below) appear to align with the goals of the ScienceBEAT initiative. The public understanding of the science of climate change, supported by digital information technology, and targeting high schools located in areas with under served populations (such as those students in Prince George’s County Public Schools) combine to suggest that the required “letter of intent” to the Foundation could provide strong arguments for support. Following the Foundation’s review of letters of intent, only invited funding proposals are accepted for review. **A letter of intent will be submitted to the Sloan Foundation on or before October 31, 2016.**

The screenshot shows the Alfred P. Sloan Foundation website. The header includes the foundation's logo and name. A search bar and a print icon are visible. The main content area is titled "Major Program Areas" and features a large image of a human eye. Below the image, a text block states: "The Alfred P. Sloan Foundation makes grants in nine broad subject matters, known within the Foundation as major program areas." This is followed by a list of program areas with brief descriptions:

- Sloan Research Fellowships**: Annual awards to 126 of the most promising early-career scholars in eight scientific and technical fields.
- STEM Research**: Grants to support original, high-quality research in the natural sciences, engineering, and mathematics.
- STEM Higher Education**: Grants to improve the quality and diversity of higher education in science, technology, engineering and mathematics.
- Public Understanding of Science, Technology, & Economics**: Grants to expand the public understanding of science and technology through the use of books, radio, film, television, theater, and new media.
- Digital Information Technology**: Grants to advance the creation, dissemination, and democratization of access to knowledge through the use of new developments in digital information technology.

Three red arrows on the right side of the page point to the descriptions for "Public Understanding of Science, Technology, & Economics", "Digital Information Technology", and "Sloan Research Fellowships".

## **CONCLUSION**

In its first year, the ScienceBEAT pilot project has been a successful (and rewarding) initiative for all team members to collaborate with campus colleagues in four different units. The deliverables and outcomes of the ScienceBEAT project thus far illustrate the many benefits of a mutually beneficial collaboration to synthesize applied research from several departments at the University of Maryland. The ScienceBEAT project also provides unique opportunities for UMD researchers to collaborate with local high school teachers and students.

The “win-win-win” benefits to researchers and high schools from only the first year of the ScienceBEAT pilot have already produced measureable outcomes that illustrate the need for continued research and development. This effort could not have been possible without the funding and forward thinking of the University’s of Maryland’s Senior Vice President and Provost and UMD’s Council on the Environment. The UMD team of researchers and graduate assistance, and the teachers from Prince George’s County, are thankful for this generous support.

## APPENDIX A Project Documents

*ScienceBEAT*

### **An Innovative Educational Collaboration To Increase Understanding of Climate Change With Active Learning**

(Companion website: [www.sciencebeat.org](http://www.sciencebeat.org))

Ross Salawitch, Professor, Department of Atmospheric and Oceanic Science, Department of Chemistry and Biochemistry,  
and Earth System Science Interdisciplinary Center, College of CMNS  
Ronald Yaros, Associate Professor, Philip Merrill College of Journalism  
Wayne Slater, Associate Professor, College of Education  
Amir Sapkota, Associate Professor, Maryland Institute of Applied Environment Health, School of Public Health  
Timothy Canty, Research Assistant Professor and Associate Director, UG & MPAO Programs  
Department of Atmospheric and Oceanic Science, College of CMNS

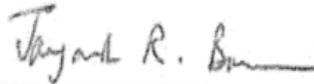
#### **Statement of Collaborative Effort**

Grounded in Next Generation Science Standards (2015) and the Common Core State Standards (2010), this proposal to develop and evaluate a series of interactive educational modules about climate change seeks to form new interdisciplinary collaborations among UMD faculty researchers from four Colleges (CMNS, Education, Public Health, and Journalism) plus teachers and students from three pilot high schools in Prince George's County.

If funded, the team seeks to develop, pilot, and evaluate classroom materials and produce meaningful results to support a subsequent proposal to the National Science Foundation's *Science, Technology and Society* (STS) program. We will also participate in future progress sessions and engage in events that bridge the Colleges to bring researchers together. Given the nature of the interdisciplinary team, we see many opportunities for validating and sharing this project with other disciplines and institutions.

#### **DEAN APPROVALS**

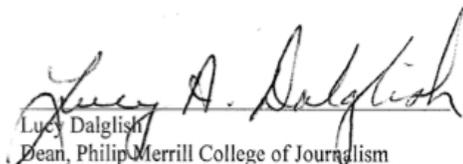
As Dean, I approve this application for the Council on the Environment Seed Grants for Interdisciplinary Environmental Research program, and if this proposal is selected, my College will provide \$15,000 in funding for this program. I understand that funding for two proposals for this program will be awarded, and will include equal funding of \$15,000 from each of three initial Colleges, the Office of Research, the Provost, and the Council on the Environment, for a total of \$90,000 per award. **An additional \$15,000 would be contributed by a fourth College participating in this proposal for a total award of \$105,000.**



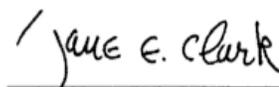
Jayanth R. Banavar  
Dean, College of Computer, Mathematical & Natural Sciences



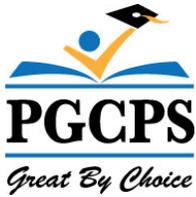
Donna Wiseman  
Dean, College of Education



Lucy Dalglish  
Dean, Philip Merrill College of Journalism



Jane E. Clark  
Dean, School of Public Health



**Godfrey Rangasammy**  
*Science Supervisor*

September 10, 2015

Kola Sunmonu, Ph.D., Director  
Department of Research and Evaluation  
Prince George's County Public Schools (PGCPS)  
14201 School Lane  
Upper Marlboro, MD 20772

Dear Dr. Sunmonu:

Grounded in the *Next Generation Science Standards* (2015), the *Common Core State Standards* (2010), and Prince George's County Public Schools' (PGCPS) *Literacy Leads to Success! Emphasize Rigorous Literacy Instruction Strategy Team Implementation: A Report and Action Plan*, this proposal to collaboratively develop and evaluate a series of interactive educational modules about climate change will form new interdisciplinary collaborations among University of Maryland faculty researchers, Prince George's County Public Schools Science and Reading/English Language Arts supervisors; and teachers and students from selected PGCPS high schools. The Maryland team will consist of Ross Salawitch, CMNS; Ronald Yaros, College of Journalism; Wayne Slater, College of Education; Amir Sapkota, School of Public Health, and Timothy Canty, CMNS. The PGCPS team will consist of Godfrey Rangasammy, Science Supervisor (PreK-12); Corey Carter, Supervisor, High School Reading/English Language Arts; Lorrie Ann Armfield, Science Instructional Specialist (PreK-12); and Karen Shaw, Reading/English Language Arts Instructional Specialist (9-12).

This proposal titled *ScienceBEAT* will partner Maryland researchers and research assistants with PGCPS high school teachers of Earth Science and English and Journalism to develop a series of innovative and interdisciplinary digital learning modules for mobile devices and online access. Please refer to the attached *ScienceBEAT* overview for more specifics. We predict that these interactive modules, which will be shared by students in Earth Science and English and Journalism classrooms, will enhance the awareness and understanding of critical climate data and more accurate communication of the effects of climate change, including public health.

In this proposed pilot phase of *ScienceBEAT*, we plan to work collaboratively with one Earth Science teacher and one English/Journalism teacher from each of three (3) high schools: Eleanor Roosevelt High School, Northwestern High School, and Oxon Hill High School for a total of six (6) teachers. The PGCPS teachers of Earth Science and English/Journalism will work collaboratively with the Maryland team to develop the climate change modules for use in their classes, grounding course development in the Next Generation Science Standards, Common Core State Standards, PGCPS's *Literacy Leads to Success*, and PGCPS learning outcomes in Earth Science, English/Journalism. All Maryland/PGCPS collaborative planning for the pilot modules will use PGCPS curriculum planning frameworks and will map seamlessly onto the current PGCPS Science and Reading/English Language Arts curriculum.

The pilot phase for implementing the modules in Earth Science and English/Journalism classes for the jointly created climate change modules is tentatively scheduled for November 2015 through January 2016. For students participating in this pilot initiative at the three proposed sites, we plan on using a pre-test/post-test design to collect attitude data focused on the climate change topics covered in the modules to assess possible attitude change (Creswell, 2015; Krathwohl, 2009). In addition, we plan on interviewing a subset of students at each site focusing on their topic-specific climate change attitudes to serve as a validity check. Then we plan on administering two (2) additional assessments: 1) an Earth Science climate change assessment and 2) a writing assessment. We will collect pre-test (prior knowledge)/post-test comprehension data (evidence based selected response items and brief constructed responses) on the Earth Science climate change module content. For the students' writing assessment, we will use the validated PARCC writing rubric for argument. Independent raters will be used to assess students' writing and inter-rater reliability will be reported. Following standard and accepted American Psychological Association (APA) research guidelines, all student identifiers will be removed for data analyses and reporting. Data collected from participating teachers will include 1) interviews on module content as we collaboratively develop the climate change modules, 2) interviews during and after the implementation of the modules focused on the effectiveness of the units, and 3) a focus group session after implementation of the modules focused on teachers' recommendations for revising and improving the modules.

Development of the climate change modules will be scheduled during two, half-day, paid Saturday workshops in October. Again, the pilot phase for implementing the modules in Earth Science and English/Journalism classes is tentatively scheduled for November 2015 through January 2016. As described above, student and teacher data collection will occur throughout the duration of the proposed pilot study.

Please consider this letter as documentation of my full support of the proposed *ScienceBEAT* initiative. I look forward to a productive collaboration with *ScienceBEAT* this year and in the future. I am looking forward to your approval of this proposed Maryland/PGCPS collaboration.

Sincerely,

Godfrey Rangasammy  
Science Supervisor (PreK-12)  
Prince George's County Public Schools (PGCPS)  
Instructional Support Services Center (ISSC)  
9201 East Hampton Drive  
Capitol Heights, Maryland 20743  
Capitol Heights, Maryland 20743

**PRINCE GEORGE'S COUNTY PUBLIC SCHOOLS**  
14201 SCHOOL LANE, UPPER MARLBORO, MD 20772 **Phone:** 301-952-6000 **Website:** [www.PGCPS.org](http://www.PGCPS.org)  
**Follow Us:** @PGCPS, Facebook, Youtube

**APPENDIX B**  
**Test Instruments Developed and Employed**

Instructions:

**Below are several statements about climate change evidence. Decide how much you agree or disagree with each statement.**

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
1. Global average temperatures have increased over the past 100 years.	1	2	3	4	5
2. Average sea levels have increased over the past 50 years.	1	2	3	4	5
3. Atmospheric greenhouse gas concentrations have been rising for the past 50 years. This is because of human activity.	1	2	3	4	5
4. Solar activity has decreased since the 1970s. The Earth has actually received less of the sun's energy. But the Earth's global average temperature has continued to rise.	1	2	3	4	5
5. Satellites measure that more of the Earth's atmosphere is being absorbed by greenhouse gases.	1	2	3	4	5
6. Before the Industrial Revolution, increases and decreases in global temperatures closely matched the increase and decrease in solar radiation.	1	2	3	4	5

**PERCEPTIONS**

Names \_\_\_\_\_

Teacher \_\_\_\_\_

Period/Class \_\_\_\_\_ Date \_\_\_\_\_

**Human-Induced Climate Change Instrument**

**Directions:** On a scale of 1-5, please indicate the extent to which you think that **MOST CLIMATE SCIENTISTS** would agree with the following statements.

	Most Scientists would <b>Strongly</b> Disagree	Most Scientists would Disagree	Most Scientists would Neither Agree Nor Disagree	Most Scientists would Agree	Most Scientists would <b>Strongly</b> Agree
1. <b>The Sun is the main source of energy for Earth’s climate.</b>	1	2	3	4	5
2. <b>Humans have very little effect on Earth’s climate.</b>	1	2	3	4	5
3. We cannot know about ancient climate change.	1	2	3	4	5
4. <b>Earth’s climate has probably changed little in the past.</b>	1	2	3	4	5
5. The Sun’s brightness is one way to measure solar activity.	1	2	3	4	5
6. Sunspot number is related to solar activity.	1	2	3	4	5
7. <b>Greenhouse gases make up less than 1% of Earth’s atmosphere.</b>	1	2	3	4	5
8. <b>Burning of fossil fuels produces greenhouse gases.</b>	1	2	3	4	5
9. <b>Humans produce billions of tons of greenhouse gases each year.</b>	1	2	3	4	5
10. <b>Humans are reducing the amount of fossil fuels they burn.</b>	1	2	3	4	5
11. <b>Greenhouse gas levels are increasing in the atmosphere.</b>	1	2	3	4	5
12. <b>Greenhouse gases absorb some of the energy emitted by Earth’s surface.</b>	1	2	3	4	5
13. <b>Earth’s climate is currently changing.</b>	1	2	3	4	5
14. <b>Humans are behind the cause of Earth’s current climate change.</b>	1	2	3	4	5
15. <b>Earth’s climate is not currently changing.</b>	1	2	3	4	5
16. <b>Current climate change is caused by human activities.</b>	1	2	3	4	5
17. Current climate change is caused by an increase in the Sun’s energy.	1	2	3	4	5

18. Current climate change is caused by the ozone hole.	1	2	3	4	5
19. Current climate change is caused by changes in Earth's orbit around the Sun.	1	2	3	4	5
<b>20. Current climate change is caused by volcanic eruptions.</b>	1	2	3	4	5
21. Current climate change is caused by increasing dust in the atmosphere.	1	2	3	4	5
<b>22. Future climate change may be slowed by reducing greenhouse gas emissions.</b>	1	2	3	4	5
<b>23. Humans cannot reduce future climate change.</b>	1	2	3	4	5
<b>24. Satellites do not provide evidence that humans are changing Earth's climate.</b>	1	2	3	4	5
<b>25. Earth's average temperature has increased over the past 100 years, and this is evidence of climate change.</b>	1	2	3	4	5
<b>26. Average sea level is increasing, and this is evidence of climate change.</b>	1	2	3	4	5
<b>27. Most of the world's glaciers are decreasing in size, and this is evidence of climate change.</b>	1	2	3	4	5

Name \_\_\_\_\_  
Date \_\_\_\_\_

Teacher \_\_\_\_\_  
Class/Period \_\_\_\_\_

### Let's See What You Learned from Module 1

Directions: Clearly indicate (for example, with a circle or check) the letter of the response that you think is the best answer.

**1. The greenhouse effect is:**

- (a) caused by human activity
- (b) a natural atmospheric process**
- (c) a result of the Industrial Revolution
- (d) found mainly in floral shops

**2. Global warming is a climate change term that describes:**

- (a) very hot weather that lasts more than three days
- (b) a sudden decrease in the Earth's global average temperature
- (c) a gradual increase in the Earth's global average temperature**
- (d) the change of weather

**3. Atmospheric heat trapped by greenhouse gases mostly comes:**

- (a) directly from the sun
- (b) from the earth's surface, which is heated by the sun**
- (c) from heat-producing chemical reactions in the atmosphere
- (d) from volcanic activity

**4. Atmospheric greenhouse gases trap:**

- (a) heat radiating from Earth, sending some of this energy back toward Earth.**
- (b) sunlight, sending some of this energy back to the Earth's surface.
- (c) heat and sunlight, sending most of this energy back to the Earth's surface.
- (d) sunlight, creating a chemical reaction that releases even more energy

**5. The six ScienceBEAT modules were designed by:**

- (a) other high school students
- (b) high school teachers
- (c) University of Maryland scientists**
- (d) app programmers

Name \_\_\_\_\_  
Date \_\_\_\_\_

Teacher \_\_\_\_\_  
Class/Period \_\_\_\_\_

### Let's See What You Learned from Module 2

Directions: Clearly indicate (for example, with a circle or check) the letter of the response that you think is the best answer.

**1. Two greenhouse gases that trap significant amounts of heat are:**

- (a) nitrogen and oxygen
- (b) methane and water vapor**
- (c) helium and sulfur
- (d) hydrogen and argon

**2. If there is a heat wave in Prince George's county next week, then most scientists would say that:**

- (a) global warming is the cause
- (b) many heatwaves would need to be examined before determining the cause

**(c) local temperatures over one week tell us more about weather than about climate.**

(d) climate has no relationship with weather.

**3. What are most responsible for the recent rise in atmospheric greenhouses gases?**

(a) spray bottles and carbonated beverages.

**(b) transportation, electricity, heating, air conditioning, farming**

(c) volcanic activity and other natural processes

(d) abandoned farmland converted into forests

**4. Natural factors that most affect the Earth's climate include:**

**(a) volcanic activity, the sun's energy output, and oceanic phenomena**

(b) forest fires, lightning, and wind

(c) earthquakes

(d) day to day changes in the weather.

**5. Methane, as a greenhouse gas, is a problem because it:**

**(a) traps more heat than water vapor and carbon dioxide**

(b) is found in greater concentrations than other greenhouse gases

(c) is highly explosive

(d) can cause severe air pollution that smells very bad

Name \_\_\_\_\_

Teacher \_\_\_\_\_

Date \_\_\_\_\_

Class/Period \_\_\_\_\_

### Let's See What You Learned from Module 3

Directions: Clearly indicate (for example, with a circle or check) the letter of the response that you think is the best answer.

**1. Most computer climate models of *climate change*:**

(a) predict the amount of precipitation in the near future.

(b) predict the strength, speed and direction of threatening weather events.

**(c) predict the long-term future of the Earth's temperature, precipitation, and sea levels.**

(d) predict the Earth's temperature, precipitation, and sea level over the next few hours.

**2. Two things that act as positive feedbacks in the climate system are:**

(a) water vapor and aerosols

(b) water vapor and clouds

**(c) water vapor and melting ice**

(d) water vapor and volcanoes

**3. Climate scientists call processes which decrease heat in the atmosphere:**

**a) negative feedbacks**

b) vicious cycles

c) positive feedback

d) thermogenesis mechanisms

**4. As sea ice melts:**

a) less heat is emitted into the atmosphere

b) more ocean is revealed, reflecting more of the sun's energy

**(c) more ocean is revealed, absorbing more of the sun's energy**

d) heat energy is released from the melting ice

**5. Which of the following is a growing problem for many cities?**

- (a) less electricity use in the winter
- (b) less snow in the winter
- (c) longer growing season in Northern latitudes
- (d) rising sea levels**

Name \_\_\_\_\_  
Date \_\_\_\_\_

Teacher \_\_\_\_\_  
Class/Period \_\_\_\_\_

**Let's See What You Learned from Module 4**

Directions: Clearly indicate (for example, with a circle or check) the letter of the response that you think is the best answer.

**1. In the future, most climate scientists predict that there will be:**

- (a) fewer hurricanes, but the strength of hurricanes will increase.**
- (b) fewer hurricanes, and the strength of hurricanes will lessen.
- (c) more hurricanes, and the strength of hurricanes will increase.
- (d) Hurricane activity and strength of hurricanes will not change.

**2. How has climate change affected glaciers?**

- (a) All glaciers worldwide have been shrinking.
- (b) All glaciers have remained the same.
- (c) Most glaciers are growing.
- (d) Most glaciers have been shrinking.**

**3. With warmer temperatures since the 1960s, crop yields have:**

- (a) stayed the same
- (b) decreased
- (c) increased, but droughts have become more common**
- (d) become more uncertain

**4. Severe weather is increasing the most in:**

- (a) North America**
- (b) South America
- (c) Africa
- (d) Australia

**5. Oceans levels are rising, and this is mainly due to:**

- (a) increased amounts of precipitation
- (b) melting of arctic glaciers
- (c) thermal expansion of water as oceans get warmer**
- (d) melting of Antarctica

Name \_\_\_\_\_  
Date \_\_\_\_\_

Teacher \_\_\_\_\_  
Class/Period \_\_\_\_\_

**Let's See What You Learned from Module 5**

Directions: Clearly indicate (for example, with a circle or check) the letter of the response that you think is the best answer.

**1. What is the expected relationship between severe heat events and heart attacks?**

- (a) No relationship between severe heat events and heart attacks.
- (b) More severe heat events mean more heart attacks.**
- (c) More severe heat events mean fewer heart attacks.
- (d) Fewer severe heat events mean more heart attacks.

**2. A critical aspect to protecting public health from climate change is:**

- (a) developing new medicines.
- (b) preparing for extreme weather events.**
- (c) nothing
- (d) going to the gym at least five times a week.

**3. A negative health outcome that becomes more likely from increasing air pollution is:**

- (a) increased food borne disease, such as salmonella
- (b) increased water borne diseases, such as cholera
- (c) asthma and other respiratory diseases**
- (d) malaria and other vector borne diseases

**4. In Maryland, asthma affects:**

- (a) between 10,000 and 50,000 people
- (b) between 100,000 and 400,000 people
- (c) between 400,000 and 700,000 people**
- (d) between 1,000,000 and 1,300,000 people

**5. Malaria, a disease spread by mosquitos, is a:**

- (a) food borne disease
- (b) air borne disease
- (c) water borne disease
- (d) vector borne disease**

Name \_\_\_\_\_  
Date \_\_\_\_\_

Teacher \_\_\_\_\_  
Class/Period \_\_\_\_\_

**Let's See What You Learned from Module 6**

Directions: Clearly indicate (for example, with a circle or check) the letter of the response that you think is the best answer.

**1. The country that emits the most carbon dioxide (CO<sub>2</sub>) per person is:**

- (a) The United States**
- (b) China
- (c) Russia
- (d) India

**2. One way to reduce your carbon footprint is to:**

- (a) drive more often and walk less.
- (b) fly more often and drive less.
- (c) consume more locally produced red meat and less vegetables.

**(d) consume more locally produced vegetables and less red meat.**

**3. The country that emits the most greenhouse gases is:**

- (a) The United States
- (b) China**
- (c) Russia
- (d) India

**4. One way to reduce your carbon footprint is to:**

- (a) order everything through Amazon
- (b) eat more red meat and less chicken
- (c) take more showers and less baths

**(d) switch to LED light bulbs**

**5. Most of our electricity is generated through:**

- (a) wind powered turbines
- (b) photovoltaic solar power
- (c) water powered turbines
- (d) coal powered turbines**

**APPENDIX C**  
**Sample of Qualitative Teacher Feedback**

ScienceBEAT Teacher Feedback on Module 3  
(Rev. 07-14-16)  
Date: 7/18 - 7/22

**1. What would you recommend adding to this module?**

A. You could add a slide or two after the description of models about the skepticism behind the accuracy of climate models. A possible source for information: <https://www.skepticalscience.com/climate-models-basic.htm>

B. Add some sort of transition slide before slide 16. It seems like you're changing topics, and it feels very abrupt the way it's currently set up.

C. Instead of slides 36 and 37, I think you should add slides that talk about the what makes one climate model different from another climate model, then follow that up with slide 38 that shows, despite their differences, that all climate models predict warming. Though, the reasons given on slide 38 don't make a lot of sense with no further explanation.

D. I would add a slide between 42 and 43 explaining what aerosols are and why they are a complicating factor in climate modeling.

E. Question: Why are slides 46 and 47 in the presentation? What is their point? They don't seem to fit With the slides that come before. If they do, that should be explained somewhere on the slides and in the teacher's guide.

F. Question: Is there a slide that goes with slide 48? I don't see where the student could compare the UMD model to others.

G. Add a transition slide before slide 49, since you seem to be moving to a brand new topic.

H. I didn't bring this up in Module 2, but if you're going to have a Big Picture slide in this module, you might want to consider having a Big Picture slide in all the modules as a sort of wrap up of the things the student learned as part of the module.

I. Add a "You will Learn" slide to the beginning of the module, like in modules 1, 2 and 6.

**2. What would you recommend changing/deleting from this module?**

A. Delete slide 2, 10, 25

B. Rephrase the open-ended question to be specific about "scientific" models/modeling.

C. For slides 4-6, the statement in the box "What a computer model looks like" doesn't really seem to fit. Should it be something more like "How a computer model is built". It also makes it seem like the "model" is the picture and not the mathematical representations of all the interactions mentioned in slide 8.

D. Question: What is the goal for having The very very simple climate model as part of the presentation. Is just to play around with, or do you want the students to do the lesson associated with it? If so, this should be made clear in the guide you include for the teachers. Since there aren't that many activities associated with the science modules, this might a decent one to include, since it's already been written, it looks decent, and most students in high school never really get a chance to do true mathematical modelingactivities. <http://scied.ucar.edu/activity/very-very-simple-climate-model-activity>

E. I would put the transition slide about accuracy before the poll question about how often the data is calculated for the model. Isn't accuracy changed by both the time frame and scale of grid?

F. Slide 14 rephrase "As computers BECAME more powerful....." since you're showing historical data.

G. I think slide 15 (activity about temp and precip changes) should be used in conjunction with \_\_\_\_\_ and come right after slide 9 "The very very simple climate model". It doesn't make much sense to me coming right in the middle of the conversation about making models more accurate.

H. Slide 16 is confusing in my opinion. You've already indicated in the explanation about modeling how scientists have to consider many factors when creating their models. How does the information you are presenting after slide 16 differ from the information you talked about before (the graphics from slides 7 and 8)? Is this a matter of distinguishing between basic models and what they included (pure atmospheric and oceanic processes) and more sophisticated information based on feedback interactions? If so, that needs to be stated somehow.

I. Slides 16 and 17 could probably be combined into one slide.

J. Slide 18 rephrase: "It's important to know the importance of" is awkward. Also, I don't think that feedback loops need to be in quotation marks.

K. Slide 19: Maybe rename the slide to "An introduction to positive feedback loops"...the way it's written now makes it seem like the initial change and response is the feedback loop.

L. Slide 20: I don't really like the definition on this slide. It doesn't make a lot of sense to me, but I am not exactly sure how it should be phrased. Somehow it needs to indicate that the "response" causes an environmental change that enhances the original response.

M. Instead of the graphic you used on slide 21, I like this one because it includes the original environmental change indicated in your feedback loop examples (humans release greenhouse gasses into the atmosphere).  
[http://www.nasa.gov/images/content/62572main\\_Image-2\\_humiditym.jpg](http://www.nasa.gov/images/content/62572main_Image-2_humiditym.jpg)

N. Changes to slide 22:

Title to "An introduction to negative feedback loops"

Change "After temperature rises..." to "After temperature rises, water vapor concentration may not be the only environmental parameter that changes" (or something to that effect).

You don't actually give an example of a negative climate-based feedback loop.

Other examples should be on their own slide since they are not examples of negative feedback loops.

The examples should all follow the same grammatical pattern "X changes, warmth causes x"

Example: 1. Humidity increases - Warm air holds more moisture

Example: 2. Ice caps decrease in size - Warmth causes ice to melt

Example: 3. The length of the growing season increases - Warmer temperature mean longer growing seasons

Example: 4. Plants could get larger: Warmer temperature mean longer growing seasons and longer growing seasons  
ould mean larger plants

c

O. Slide 24 should have a title.

P. Slide 27 should not have a change in font color.

Q. Slide 30 rephrase: "Ice cover is a positive feedback in the climate system because melting sea ice enhances the original environmental response to increased greenhouse gasses (warming temperatures).

R. Not sure we need slide 31, but if you keep it, take out the words "3 steps to".

S. I think we should delete Slide 34, but if you keep it, it should be introduced in a way that indicates that not all feedback systems are as straightforward as the first two examples given. Also, if you keep it, you add slides indicating one way cloud cover could be positive feedback and one way it could be negative feedback.

T. I think you should delete slides 36 and 37 the way they currently are. You could replace them with a slide that actually explains the concept of Representative Concentration Pathways.

U. What's the difference between slides 39 and 40? What is the y-axis for these slides? What does CRU and RCP mean?

V. Slide 41, no parentheses around probabilities and predictions should be plural.

W. Slide 45, I think it should say "the extent of future warming is uncertain" since the idea is that no what, it is going to warm, we just don't know to what degree the warming will occur.

X. Slide 51 - The y-axis label should be more than (m). There needs to be explanation of the different RCPs.

Y. I really like the idea of slide 52, but I don't see where it belongs in the module at all. Perhaps in Module 2? If you keep it for any module, you need to indicate what the different colored lines mean (I assume they are predictions from different models?). Also, add a degree symbol to the (C) in the title. Also, the x-axis label is confusing...latitude is not normally talked about in negative numbers.

Z. The Big Picture slide needs to be revamped.

If you're going to have the first bullet point in the list, it be noted that this was a conclusion from module 2, because the first bullet point has nothing to do with Module 3. If you're only focusing on the big picture from Module 3, the first bullet point should be taken out.

The second bullet point is a little confusing for me. It makes it seem like the Aerosol question is the only reason future warming is uncertain. That's not true, is it? That's just one example given?

The second bullet point should be re-worded indicating that we know warming is going to happen, but the degree of warming is uncertain.

The last bullet point does not appear to have anything to do with Module 3 and should be taken out.

### **3. What necessary background information needs to be included with this module to enable teachers to scaffold effective instruction? How would you incorporate this information into the module?**

A. There should be an explanation about basic computer modeling (what it is, how it works, how they are created). Many teachers have no background in computer models, and it might be hard to explain on their own.

B. There needs to be an explanation included in an educator's guide about how the scale of the models affects the accuracy of the models, both in terms of the size of the grid size and time frame (how often the data is calculated for each grid).

C. The examples on Slide 22 should have explanations for the teacher in case students ask how they are feedback loops (and whether they are positive or negative).

D. The connection between why all models predict warming and the reasons given on slide 38 require more explanation. It doesn't make intuitive sense to me how the reasons given connect to the question of why all models predict warming. If you use this slide, you need to give teachers more background information to help explain slide 38.

E. Slides 41-45 need a lot of explanation so the teacher knows what they're presenting. What do all of the axes mean? What's the black line? What's the difference between the red and blue areas. Does the historical data follow more closely with the red or blue probabilities? On slides 43 and 44, what do a, b, and c mean (I have no idea, personally). How do they lead to more/less warming?

**4. Which student activities did you like in this module? Which do you suggest be revised or removed? Finally, do you have any suggestions for the inclusion of more engaging student activities for this module?**

As suggested in 2D, you could add the student activity based on the The very simple climate model. Otherwise, there were no student activities to speak of.

**5. What are the important objectives of this module that you would like to emphasize in your instruction?**

The most important objective for me would be to get students to understand what a climate model is and what it does (and does not) do. Pointing out the complexities is also important. This is also a great opportunity to learn about feedback loops, so I would definitely emphasize those examples.

**6. List the PGCPS learning outcomes this module will address with your suggested revisions.**

NGSS Performance Expectation Statements: HS-ESS3 Earth and Human Activity. These statements encompass all three aspects of NGSS - Disciplinary Core Ideas, Science and Engineering Practices, and Cross-Cutting Concepts.

Students who demonstrate understanding can:

HS - ESS3-1

Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

HS-ESS3-5

Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

HS -ESS3-6

Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

**A breakdown of the performance expectations into the three dimensions -**

**Disciplinary Core Ideas**

ESS3.D: GLOBAL CLIMATE CHANGE - How do people model and predict the effects of human activities on Earth's climate?

Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5)

Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)

**Science and Engineering Practices**

Practice 2 - Developing and Using Models

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system

#### Practice 4 - Analyzing and Interpreting Data

Analyze data using computational models in order to make valid and reliable scientific claims.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations

#### Practice 5 - Using Mathematics and Computational thinking

Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.

#### Practice 6 - Constructing Explanations and Designing Solutions

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion

#### Practice 8 - Obtaining, Evaluating, and Communicating Information

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

### **Cross- Cutting Concepts**

#### CCC 2 - Cause and Effect

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

#### CCC 5 - Systems and System Models

When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

#### CCC 7 - Stability and Change

Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Feedback (negative or positive) can stabilize or destabilize a system.

### **7. Are there any additional PGCPS learning outcomes you recommend including?**

#### CCSS.ELA-LITERACY.RST.11-12.7

Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

#### CCSS.ELA-LITERACY.RST.11-12.4

Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11-12 texts and topics*.

**8. Add any additional comments to further improve this module.**

A. Picking a theme for the slides and sticking with it. There is a lot of alternating between the blue background slides, the all black slides with white writing, and the all white slides with the blue writing. .

B. The Module 3 Quiz:

The other quizzes aren't called pop quizzes, this one shouldn't be either.

Be sure to number and label the quiz questions consistently (question 1, 2, 3...answer choices A., B., C., D).

I think there should be a standard number of quiz questions (5 might be nice). So this one would need one more because....

I think you should replace question 1 because I think the slide it references should be taken out of this module (as noted in 2Y). Also, even if you keep that slide in this module, it's one of 53 slides and not even close to being a main point of the module.

Question 2: I don't think the answer reflect the way a positive feedback loop is described in the module and should be re-worded.

Question 3: The answer to question 3 is not really mentioned anywhere in Module 3 and should probably be replaced.

Question 4: Re-worded "Most computer climate models" or "Most computer models of climate change".

Question 5: Should be replaced because it has nothing to do with Module 3.

If you're going to have questions based off of previous modules, you should have longer quizzes for every module. (Maybe a base of 5 questions from the current module and 1 or 2 questions from each of the previous modules).

**APPENDIX D  
Paid Receipts (Licenses)**

Nearpod Inc  
 18305 Biscayne Blvd. Suite 301 Aventura, Fl 33160  
 University of Maryland  
 College Park, MD 20742

Description	Qty	P.O. No.	Terms	Project
			Net 30	
Description	Qty	Rate	Amount	
Nearpod School Edition for 25 Teachers *Unlimited content to all users including CSM's Digital Citizenship * Licenses will be valid from 8/14/2015 to 8/15/2016  PLEASE REMIT PAYMENT TO:  Nearpod, Inc. ATTN: Accounts Receivable 18305 Biscayne Blvd. Suite 301 Aventura, FL 33160  MAKE CHECKS PAYABLE TO NEARPOD, INC CREDIT CARDS WELCOME  Payment of entire invoice amount is required within 30 days from invoice date.  BANK OF AMERICA COMPANY NAME: NEARPOD INC ACCOUNT NUMBER: 229046324644 ROUTING NUMBER/ABA: 026009593 (wires) 063000047 (paper) 063100277 (electronic) SWIFT CODE: BOFAUS3N	1	2,700.00	2,700.00	
Thank you for your business.		<b>Total</b>	<b>USD 2,700.00</b>	
		Payments/Credits	USD -700.00	
		Balance PAID	USD 2,000.00	

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Invoice

**Balance Due**  
**\$749.50**

**Appy Pie LLC**

340 S LEMON AVE #1831  
WALNUT CA 91789  
U.S.A

Invoice Date : 12 Sep 2015  
Terms : Due on Receipt  
Due Date : 12 Sep 2015

Item & Description	Qty Amount	Rate	Discount	
Platinum Lifetime plan for University of Maryland - ScienceBEAT Project	1.00	1,499.00	50.00%	749.50
			<b>Sub Total</b>	749.50
			No Tax (0%)	0.00
			<b>Total</b>	<b>\$749.50</b>
			<b>Balance Due</b>	<b>\$749.50</b>

Balance PAID=\$749.50